Construction Materials Testing and Quality Assurance Study

Arizona Department of Transportation

Construction Materials

Testing And Quality Assurance Study

December 16,1987

ACKNOWLEDGEMENTS

The committee would like to offer special thanks to Mr. Jim McGee who participated as the team leader for this study. Mr. McGee's personal character and leadership was inspirational to this committee; without it this project would not have been possible.

On behalf of ADOT we would also like to thank IBM for providing the Application Transfer Study service. This process was extremely beneficial to ADOT and hopefully will have a significant impact on ADOT's ability to improve our construction testing and reporting procedures.

The study team consisted of the following personnel:

ADOT

Paul Bolster, Tr. Engineering Specialist
Don Dorman, Tr. Engineering Specialist
John Daru, EDP Manager, Information Systems Group
Don Green, Tr. Engineer Supervisor
Jim McGee, Deputy State Engineer, Highway Operations
Larry Scofield,Tr. Engineer Supervisor

IBM

Kris Barr, System Engineer
Jim Bertsch, Application Specialist
Larry Hanson, Application Specialist
Katie Underwood, Marketing Representative

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EXECUTIVE SUMMARY

The ADOT recognized a need to improve the consistency and timeliness of our construction materials reporting and quality assurance on state transportation projects.

The ADOT established a joint ADOT/IBM study team to determine current and long-range highway operations requirements, to prepare a plan that will meet those requirements, and to evaluate the cost/benefits of that plan. In pursuit of their mission, the study team interviewed 55 individuals who represented a broad spectrum of Highway Operations field engineers, management, lab technicians, and staff personnel from rural, suburban, and headquarters locations. These interviews resulted in approximately 189 statements addressing apparent needs, from the perspective of the interviewee. These statements were then consolidated into 10 major summary statements which represented Highway Operations materials testing information requirements.

The study team then strove for an information system solution that would satisfy these requirements. Through study team consensus it was determined that Highway Operations required an automated information system that was based on a single integrated data repository for all materials test data. The system must provide access to that data, as well as manipulative and analytical functions to work with the data, for all Highway Operations personnel as required for operational usage, analysis, and product preparation.

The solution calls for an investment of approximately $1.5 million to $2 million of automation hardware and software, Highway Operations personnel, and data processing personnel (either ISG or contract) over an 18 month period. Although this is a significant enterprise for Highway Operations, the potential benefits to be derived are equally significant and could ultimately approach upwards to $2.4 million per year in improved productivity, more effective use of personnel, and consequently, better response to construction program needs. Based upon the above costs and that obtainable benefit ADOT would receive payback on their investment during the third year after initiation.

It is the study team's unanimous and strong recommendation that the ADOT commit the necessary funding and authorize the project initiation in a most expeditious manner.

INTRODUCTION

INTRODUCTION

The first attempt at automating ADOT's construction materials testing and reporting occurred in 1981 in the Flagstaff District. A lab technician independently developed a program for use in a field construction laboratory to calculate and report test results.

Although this program fulfilled the needs of the developer, little additional effort occurred in this area and very little use of the program outside of the developer's office occurred.

In 1984 research funds were used to purchase one microcomputer for each of the four Districts. A basic program was developed for calculating, reporting, and transmitting materials test results. After several years of limited support, it was evident that the program lacked the features necessary to be widely accepted and utilized at the project field office level.

At this same time (1984) another research project was initiated to automate the Central Materials Laboratory using bar code technology. After considerable effort, it was realized that the proposed technology was not adequate and the effort terminated.

In 1986 research funds were again sought to improve the construction materials testing and reporting procedures. Previous efforts indicated a lack of management support and the need for a system wide design. Therefore, a concerted effort was made to canvass other agencies for available experience and systems.

During this discovery phase, it was learned that the IBM Application Transfer Study (ATS) technique had been successfully utilized by other agencies to resolve similar problems.

The ATS approach consists of forming a team of selected agency and IBM representatives to address specific issues in a systematic manner. The thrust of the effort involves interviewing agency personnel knowledgeable in the problem at hand, analyzing the problems, and formulating specific solutions.

In October 1987 ADOT and IBM participated in an ATS study to determine what ADOT needs to do to improve the consistency and timeliness of our construction materials reporting and quality assurance on construction projects. The executive sponsor for ADOT was Mr. Owen Ford-Assistant State Engineer. The ADOT team members included Mr. Jim McGee-Deputy State Engineer, Mr. Don Green-Quality Assurance Eng., Mr. Larry Scofield-Tran. Eng. Sup., Mr. Parker Gregg-Information

Systems Group, Mr. Don Dorman-Tran. Eng. Spec., and Mr. Paul Bolster-Tran. Eng. Spec.. IBM representatives included Dr. Jim Bertsch-Application Specialist, Mr. Larry Hansen-Application Specialist, Ms. Kris Barr-Systems Eng., and Ms. Katie Underwood-Marketing Representative. During the course of the study Mr. Gregg was replaced by Mr. John Daru.

STUDY METHODOLOGY

ATS APPROACH

The ATS process begins by identifying the executive sponsor and team members to participate in the study. Once selected, a "kick off" meeting is conducted by the executive sponsor to charge the committee with the responsibility of accomplishing the designated mission. The executive sponsor, and a significant portion of the study team, are agency personnel.

The study team concentrates approximately half its efforts in conducting interviews with agency personnel to identify all the elements of the problem. The results of these interviews are then evaluated and presented in capsule form to the executive sponsor at a mid-point briefing.

The intent of this meeting is to obtain confirmation on the direction of the study and to obtain approval to proceed with the system design and economic justification.

The remainder of the study effort is directed at developing the recommended solutions, cost benefit analysis, and final report. The study findings and final report are presented to the executive sponsor in a final presentation.

ADOT ATS APPROACH

The study conducted at ADOT lasted for seven weeks ,3 days/week, and consisted of seven elements; Study Strategy, Interview Process, Problem Analysis, Solution Identification, Cost/Benefit Analysis, Implementation Plan, and Presentation of Results. These elements are discussed below.

STUDY STRATEGY

Due to the nature of this problem, the team elected to conduct interviews on personnel representing every level of involvement with construction materials testing and reporting. During the course of the study interviews were extended to include representatives from contracts and specifications and pavement design services.

Five questions were developed for the interviews. The questions were sent to each of the interviewees prior to their arrival at the meeting. Additionally, a brief description of the process and mission was included.

INTERVIEW PROCESS

Fifty-five employees were interviewed in 34 separate interviews. Interviewees ranged from field inspectors to the Deputy State Engineer. Interviews were generally conducted with one individual at a time but some interviews had as many as four people. The responses to the questions and additional comments were not discussed outside the meeting room.

PROBLEM ANALYSIS

189 problem statements were identified by the interviewees. These were evaluated for similarity and condensed into 10 statements by the study team. The significant reduction in statements was necessary to meaningfully address the problems in the short period of time with the limited resources. The identified problem statements are included in the appendix.

SOLUTION IDENTIFICATION

Potential solutions were identified and analyzed for applicability and cost effectiveness. A communications expert was brought in by IBM to provide additional expertise. Due to the remote nature of many ADOT construction field offices, special consideration was warranted.

Once a satisfactory solution was developed, system requirements were determined and a cost analysis performed. The resulting system addressed both the immediate needs for an economical solution while still addressing future expansion.

The recommended solution included both commercial software and the need for custom programming. The desired hardware architecture was established with recommended devices designated.

COST/BENEFIT ANALYSIS

To develop realistic costs for the present methods of operation, limited time studies were performed at an area lab. Additionally, considerable phone canvassing was performed to supplement this information with as broad an experience background as possible.

Costs for the equipment and software were provided by IBM.

IMPLEMENTATION PLAN

A recommended implementation plan was developed which provided not only critical path scheduling but also the resource requirements to accomplish the tasks. These items included preparation of bid documents, equipment procurement, installation and field testing.

PRESENTATION OF FINAL RESULTS

The findings of the study team were presented to the executive sponsor on December 16, 1987 and are detailed in this final report.

CURRENT ENVIRONMENT

CURRENT OPERATING ENVIRONMENT

A. - HIGHWAY OPERATIONS

The portion of the Highway Operations Group that is directly influenced by this proposal consists of the Construction Districts, the Construction Section and the Materials Section. The data and information transfer between these organizational elements is effected by voice transmission, through the mail and on occasion by communications software through the mainframe or micro-computer to micro-computer. The current electronic transfer is far from satisfactory.

The Construction Section is charged with a quality control function that requires Staff Engineers to review the records of Construction Projects during that process. These individuals must rely upon past-tense reporting to schedule their activity. In addition, valuable field time is spent pouring over laboratory test reports and the logs of the same during field inspection.

The Construction Section is often required to review Change Orders, Claims and proposed specification changes. All research for these activities must be accomplished manually. This is generally time consuming and yields less than complete information.

The Executive Management of this Group must depend upon information transfer by telephone or mail to formulate opinions with respect to construction problem areas. Their timely access to project specific information is nonexistent. Therefore, they must depend upon other opinion with respect to Change Orders or Claim research. This research may be of incomplete files that are maintained in the headquarters area. Consequently, the decisions regarding these issues are not generally timely and may be based upon incomplete information.

B. - PROJECT AND DISTRICT MATERIALS TESTING

At the present time, the construction materials personnel are spending a reported 50 percent of their time processing paperwork. Some have reported as high as 72 percent; but, few have reported less than 50 percent. These tasks vary widely, depending on the type of construction. None the less, they are highly redundant.

All materials incorporated into any construction is either tested or accepted on the basis of manufacturer's certification. Each material that is tested requires an identification card. When the sample and its identification arrive at the laboratory, the identification information is manually transferred onto a laboratory log that is used for the purpose of tracking samples through that facility. This same information is also placed upon each laboratory card and subsequent report that is generated from the testing of each sample. The general information consists: the project, the project supervisor, the type of material, source of material, type of sample, and some additional information as necessary.

A laboratory work card is prepared for each sample which contains the sample identification information, the specifications and a listing of the required tests. After each laboratory and field test are completed, a specified individual is assigned the task of checking all calculations. In addition to the testing and checking, a series of reports known as logs are prepared by either Laboratory or Project personnel. They are identified as; 1.) Weekly Lab Logs, 2.) Embankment Logs and Charts, 3.) Concrete Cylinder Logs, and 4.) Other Locally Determined Records. In addition to the testing associated activity, each manufacturer's certification must be manually reviewed, verified and logged.

The tasks described above are routine and provide only normal documentation. Any exception reporting or trend analysis is in addition to normal documentation. However, there is a common need for these analyses of material that is of questionable consistency or quality.

The normal documentation procedures, described above, are not used to administer projects. It is only used as documentation and reporting for numerous other ADOT and FHWA authorities.

Practically all of the communication necessary to administer the day to day construction is performed by telephone, radio, or personal contact. The key information or important information, regarding any difficulty is determined by project personnel. When this information is passed on, by telephone or radio, to some "Expert" it may be incomplete and sometimes based upon personal bias. Consequently, conclusions based upon the transferred information may not be the most expeditious or cost effective.

Communication between the Area Labs and project offices is usually accomplished by telephone when failing tests are involved. This appears effective, providing the phone message is accepted by a responsible individual at the project office. Otherwise, communication is effected through the inter-departmental mail, which generally takes two days at best. Consequently, trends cannot be analyzed as they occur.

The present control over the quality of materials is executed in a variety of ways throughout the State. The Resident Engineers in District I and a portion of District II delegate a major portion of the materials administration to the Area Laboratories. This is due primarily to production occurring in a limited number of rather uniform Commercial Sources. An occurrence of noncompliance is administered by the materials support function of the Area, District and sometimes, the Central Labs, without the intervention of the project administrators.

The materials produced in the outlying areas are generally more inconsistent and variable than those produced in the major metropolitan areas. Generally, materials are produce from sources that have no history or record of poor performance. The production tools consist of portable aggregate and product plants that require more intensive inspection than established Commercial Plants. These situations require specific project management level administration of noncompliance with only concurrence from District and Central Offices.

Materials produced to a statistical acceptance plan may not perform satisfactorily, even when accepted at full payment. In these situations, timely availability of all test characteristics may establish a parameter that, through experience, will indicate potential poor performance. This may allow contract revisions to occur prior to unknowingly constructing a poorly performing facility.

Better product control results when trend analyses or statistical evaluations are available. However, the current system only allows these attributes through a manual effort or from some applications software that is cumbersome to use. Therefore, these techniques are rarely utilized for any decision making with respect to materials production.

C. - MATERIALS SECTION AND CENTRAL LABORATORY

The Materials Section is a support function to the Highway Development Group as well as to the Construction Districts. The Geotechnical and Pavement Services support project development by developing the pavement structure designs and provide recommendations for contract specifications. Materials Services supports this activity by developing specification language for some materials related items.

The Central Laboratory and Materials Services supports contract administration through the performance of acceptance tests on bituminous products, portland cement, reinforcements and specialty items. In addition, Materials Services provides assistance in determining acceptable asphaltic concrete and portland cement concrete. This expert advise is sometimes not effective due to the unavailability of complete project files in the Laboratory office.

Each Construction ORG transmits copies of their "Weekly Reports" to the Central Laboratory to form records for review. These records are maintained manually and seldom represent anywhere near complete information. However, they are continually maintained by manually sorting and filing in the same fashion as the project records and those kept at each District Office.

The results of acceptance tests performed in the Central Laboratory on samples secured at the project are forwarded to the project offices through the inter-departmental mail or by telephone, in the case of noncompliance. In any event, the test results do not reach the project office in a timely manner. The Central Laboratory's total efforts, including those for geotechnical support, are hampered due to the lack of laboratory automation.

The Quality Assurance Branch of Materials Services requires project information for analyses to further develop this program for the Department's goals and the requirements of the Federal Highway Administration. Currently, all information must be retrieved manually from the files maintained in the Central Laboratory that are generally incomplete. Therefore, the lack of accurate and complete information from the construction process is a serious impediment to the development of a valid quality assurance program.

SUMMARY OF PROBLEM STATEMENTS

INFORMATION = RESOURCE

Our data and information is an important resource. Yet, we have not provided for the overall planning direction, organization and control of this resource.

* Decisions based upon incomplete information

* Inconsistencies

* Incompatible systems

* Duplication of efforts

* Misdirected Efforts

* Lack of technical information support

* Audit Trails

The interviewees identified these elements of this Summary Statement. The overall planning and direction of this resource is hampered by the manual nature of the system. The conceptual solution will provide a vehicle to greatly minimize the effects of the elements of this statement.

ANALYSIS

We lack the ability to perform analytical and statistical techniques on our test data to provide information in a useful format and in a timely manner.

* Exception reporting

* Trend analysis

* Forecasting

* Quality Assurance

The manual system does lend itself to these types of analyses as most all information must be collected manually and entered into an application software to perform the required task. The conceptual solution does address these needs to the extent the data will not have to be re-entered for analysis.

ACCESSIBILITY

We do not have the ability to access test results and specifications easily and in a timely manner.

* Current test results

* Historical test results

* Quality Assurance

The current system only allows access to information through manual file searching. However, there is a need by a number of personnel throughout the Department to require complete information on a project specific basis. The conceptual solution solves the access problem.

COMMUNICATIONS

There is a need for better communications between field, district and central office.

* ADOT expertise

* Telephone / radio "tag"

* Failing test results

* Scheduling

* Mis-communications

The interviewees indicated there were difficulties in communication within the Department. In some cases, there is a need to contact central office expertise to solve a potential construction problem or simply communicate from laboratory to project office. This situation is minimized in the conceptual solution.

CREDIBILITY

There is a perceived lack of credibility in some test information provided to management, contractors, and central lab.

* Materials certification

* Check and balance

* Accuracy

* Completeness

The complexity of the current system does not support a credible function. The solution of the previous Summary Statements will serve to greatly increase the credibility of the proposed system.

TRAINING

There is a need for:

Cross training and cross orientation of Construction Technicians

Additional training in testing procedures, evaluation and interpretation of test results for Lab Technicians

Additional training for Project Supervisors and Resident Engineers in specification interpretation and evaluation of test results

The Department is currently involved in many training programs. However, the interviewees expressed a need for more specific training in actual job related activity.

PROCEDURES

There is a need to change our Quality Assurance procedures in:

Sampling

Testing

Reporting

Certification

Inspection

Facilities

Consideration should be given to streamlining the items identified in this Summary Statement. There are many cumbersome and redundant procedures that will be modified by automation. However, changes in philosophy may have to occur before some procedures will become more efficient.

At the time of the mid-point review, 5 Summary Statements were identified as being outside the capabilities of the study group to provide recommendations for solution. However, as the Summary Statements represent the opinions of the Department's staff, the Study Group is obligated to present these problem statements to Management. The following represents those Summary Statements along with a few brief comments.

WORK LOAD

We lack the ability to perform all required functions due to:

Limited personnel resources

Geographical distance

Seasonal Scheduling

Lack of District input into project scheduling

Funding inconsistencies

Lack of control over the Contractor's Scheduling

Inexperienced personnel

Personnel relocation problems

The interviewees expressed the opinion that they are hampered from effectively performing quality service due to the items listed in this Summary Statement. Many of these items are even beyond Executive Management control. However, consideration should be given to these situations in order to have maximum efficiency and quality with the current limited personnel resources.

As an example, the Federal Highway Administration currently desires the Department to perform one independent assurance test for each 10 acceptance tests. The Department reached an agreement with F.H.W.A. to perform one independent assurance test for each 40 acceptance tests. This was based upon the provision that several other programs remain in place, including the Correlation Sampling Program. This program is no longer mandated by F.H.W.A.; therefore, it could be eliminated.

In view of the agreement, the Department currently performs some type of quality assurance activity at a frequency of one test for each 4.5 acceptance tests, in lieu of the mandated 1 in 10. The mandated 10 percent, 2.5 percent in our case, does require independent sampling; whereas, the 1 in 5 splits are sampled by project personnel. This issue should be given careful consideration with respect to the efficiency of the entire system. At a greater frequency, the independent assurance sampling could be performed from statistically based hypothesis rather than on a specified uniform frequency. This procedure would provide a more meaningful scientific evaluation of quality assurance.

CONSULTANT RELATIONSHIPS

There is a need to re-evaluate our relationships with our consultants in:

Project Development

Materials Testing

Surveying

Contract Administration

The interviewees expressed the consultants that are providing service to the Department, through consultant contracts or contractor surveying, do not understand our procedures. Consequently, Department personnel spend large amounts of time attempting to train the consultant in proper procedure. Furthermore, the consultant contracts are not being made available to the Project Administrators. Therefore, they are not aware of what sanctions can be taken against a consultant for nonfeasance or malfeasance of duty. In general, the contracts should be more specific in these areas.

MISCELLANEOUS

There is a need to:

Predict pavement design performance and reliability

Know the status of aggregate pits

Enhance our career development program

Know the status of projects under development

These items were identified by some interviewees. Consideration should be made as appropriate.

FUTURE ENVIRONMENT

FUTURE OPERATING ENVIRONMENT

A. HIGHWAY OPERATIONS

The proposed system will provide a database that may be accessed from a number of locations. The database will include all validated materials testing information.

The Construction Section's Quality Control Branch can use the database information to schedule field inspection in a more timely fashion, thereby reducing nonproductive efforts. In addition, the records and sample frequency may be reviewed in the Headquarters Office in advance of the actual field inspections. This capability will allow the staff engineers to focus their attention and expertise upon assuring that Federal and Department guidelines are met in lieu of spending untold amounts of time reviewing the paper trail for the sake of procedure.

The Construction Section's access to all information will enable them to more intelligently comment upon the administration of Change Orders, Claims and proposed specification changes. The proposed statistical techniques will be especially important in assessing specification changes, as well as the ability to perform modeling, forecasting and trend analysis.

B. - PROJECT & DISTRICT MATERIALS TESTING

The project laboratory, either project specific or Area Laboratory, will receive a sample and input the general information into an automated system. This will serve as the only input of this information that will follow the processing of each sample from receipt at the laboratory to archives. As the sample is tested, the system will perform all necessary calculations, apply appropriate specifications, flag all characteristics of noncompliance and generate any required reporting upon request.

The system attributes will allow the input of Standard Specifications into a database that is accessible to all users. Therefore, the only project input will be the Special Provisions at the beginning of the Project, as the database will marry those specifications to the project specific files.

Once the test and sample information is stored, the sorting and manipulation techniques will allow any type of report format to be generated and any type of analysis to be performed at the stroke of a few keys. The database may be queried by the Testing Laboratory, Resident Engineer, Area Engineer, District Management or the Central Office any time after the data is validated. This type of data management eliminates the need for the redundant reports and redundant copying that is susceptible to transcription errors. Any user of this information may have immediate access in a format of his pleasing.

These technically feasible functions would virtually set the qualified materials technician free to supervise testing procedure, sampling technique, sampling frequency and many other tasks more worthy of his specialized abilities. Furthermore, statistical evaluation, charting, trend analysis, and exception reporting would be immediately available, which would provide a complete informational foundation for administrative decision making.

The enhanced communication capabilities will provide statewide access through the use of an electronic mail system. Noncompliance test results may be posted in the system for a Resident Engineer to access from any point in the system. This will eliminate the problem of poor or incomplete communication.

C. - MATERIALS SECTION AND CENTRAL LABORATORY

Pavement Services will utilize the database to enhance their pavement evaluation process and pavement performance modeling. This is of special importance in being able to forecast the service life of the Departments Highway System with respect to the quality of materials incorporated into the Construction. The data base will provide important information that can be utilized in designing pavement rehabilitation techniques and developing specification recommendations. The easy access of this information will definitely encourage its use that will result in a superior product for the traveling public.

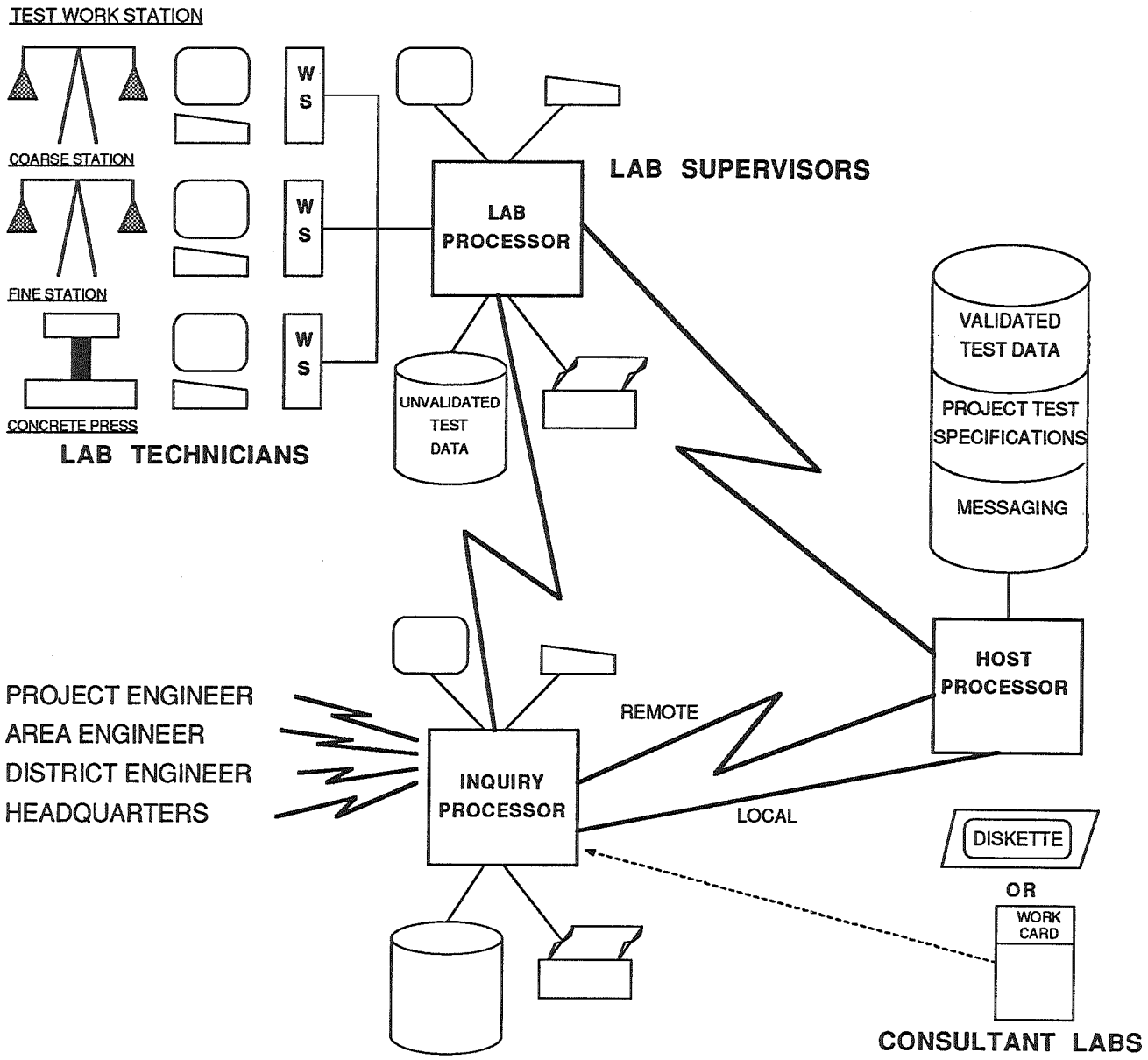
The automation of the Central Laboratory will allow the results of tests performed upon acceptance samples to be entered directly into the database. Consequently, that information will be immediately accessible to project personnel. This is of special importance with bituminous materials where penalties may be involved and with reinforcement in noncompliance that may incorporated into the structures. In addition, this automation will aid the Central Laboratory in the support of the geotechnical efforts of the Section. Another feature of this effort is that it does create an audit trail that can be easily tracked and verified.

The Materials Engineer and the Materials Testing Engineer are consistently involved in materials related problems that arise throughout the State. These difficulties require immediate attention and solution as they generally, if not always, involve an expensive construction process. The availability of all test information in the database that is immediately accessible will allow better decisions to be made in a more timely manner. This will reduce potential Change Orders and Claims.

The Quality Assurance Branch will have access to all construction test information and frequency from the proposed database. This will allow that Branch to monitor the defined program for performance, as well as providing information to improve the total program. The proposed statistical procedures will certainly enhance the investigation of variance contributions from product, sampling and testing. In addition, hypothesis testing will validate the elements of the quality assurance program.

RECOMMENDED CONCEPTUAL SOLUTION

ADOT MATERIALS TEST SYSTEM



IMPLEMENTATION TASKS

The ADOT Materials Testing Study team identified five major project areas which need to be addressed during the implementation of the proposed solution.

The five project areas are:

A. Provide timely access to department test data and test results.

B. Provide the ability to analize test data and test results.

C. Provide better communications between department personnel.

D. Establish a function responsible for the management of the department's information resource.

E. Perform other necessary tasks which do not fit into one of the above categories.

The following pages define the tasks within each project area.

ARIZONA DEPARTMENT OF TRANSPORTATION

INDIVIDUAL IMPLEMENTATION TASKS

A. ACCESS OF DATA

1. Develop system data specifications. (Elements, timing, recording)

2. Size the volume of data to be supported and determine the quantity of historical data and specifications to be maintained.

3. Determine the number of users, their locations and their frequency of use.

4. Perform overall system design. (Laboratories, construction and highway operations.)

5. Design Laboratory system. (test equipment, interfaces, test algorithms)

6. Investigate affected policy procedures.

7. Evaluate and determine appropriate "release of data". from the Laboratory Processors to the Host Processor.

8. Select hardware. (Laboratory Workstations, Laboratory Processors, Inquiry Processors and Host Processor)
Select software. (Operating Systems, Communications System, Database Systems, Programming Languages)

9. Procure system

10. Program the Laboratory Processor system. (test equipment, interfaces, test algorithms.)

11. Program the Inquiry Processor system.

12 Survey and design physical facilities for Host Processor, Laboratory Processors and Inquiry Processors.

13. Install and test the Host Processor.

14. Collect data and specifications of current projects and enter into the Host Processor.

15. Write Host System, Laboratory Processor and Inquiry Operating Procedures.

16. Install Laboratory Processors.

17. Laboratory Technician Operator Orientation

18. Provide management and user support.

ARIZONA DEPARTMENT OF TRANSPORTATION

INDIVIDUAL IMPLEMENTATION TASKS

B. ANALYSIS OF DATA

1. Identify necessary statistical and analytical techniques. (modeling, forecasting, sorting, extracting) and select the necessary software.

2. Select the necessary Statistical and Analytical software for the Host Processor

3. Define desired standard output formats for the Laboratory and Inquiry Processors.

4. Install and test the software on the Host Processor.

5. Write the Operating Procedures for accessing the Analytical and Statistical programs on the Host Processor from the Laboratory and Inquiry Processors.

6. Train Department Management, Engineers and Technicians in the use of the Analytical and Statistical programs.

7. Provide management and user support.

ARIZONA DEPARTMENT OF TRANSPORTATION

INDIVIDUAL IMPLEMENTATION TASKS

C. BETTER COMMUNICATIONS

1. Evaluate current data communications system and identify locations lacking access.

2. Design a communications system to support the collection and dissemination of messages for Highway Operations and to run on the hardware and Operating System selected to support the ADOT Materials Test System.

3. Select software compatible with C.2.

4. Install and test the system.

5. Train Highway Operations personnel in the use of the system.

6. Provide management and user support.

7. Additional tasks after implementation.

    a. Validate Testing Network to Highway Network.
    b. Evaluate existing Highway communications equipment to support the Materials Testing System.
    c. Determine Highway Department communications volume vs Materials Testing Network volume.

ARIZONA DEPARTMENT OF TRANSPORTATION

INDIVIDUAL IMPLEMENTATION TASKS

D. INFORMATION AS A RESOURCE

1. Establish a full time responsibility and authority within Highway Operations to manage information and automation. This function should report directly to the Deputy State Engineer.

2. Establish the necessary procedures to provide information systems support to all levels of Highway Operations.

3. Establish a management education program.

ARIZONA DEPARTMENT OF TRANSPORTATION

INDIVIDUAL IMPLEMENTATION TASKS

E. OTHER SYSTEM TASKS

1. Develop a program to reference required:

   a. Materials Test criteria (eg. 80-100% passing 3/4" sieve.)
   b. Submittals
   c. Certificates
   d. Test Results
   e. etc. for construction projects.

2. Investigate field data collection technologies and make recommendations for improving the identification of test samples.

3. Develop a program to validate that the proper number of tests have been taken for the materials produced.

   (The system will have a record of the actual number of tests taken. If a methodology is developed for determining the number of tests required,the system will be able to make the comparison.)

4. Develop a program to advise management of critical failures and important issues.

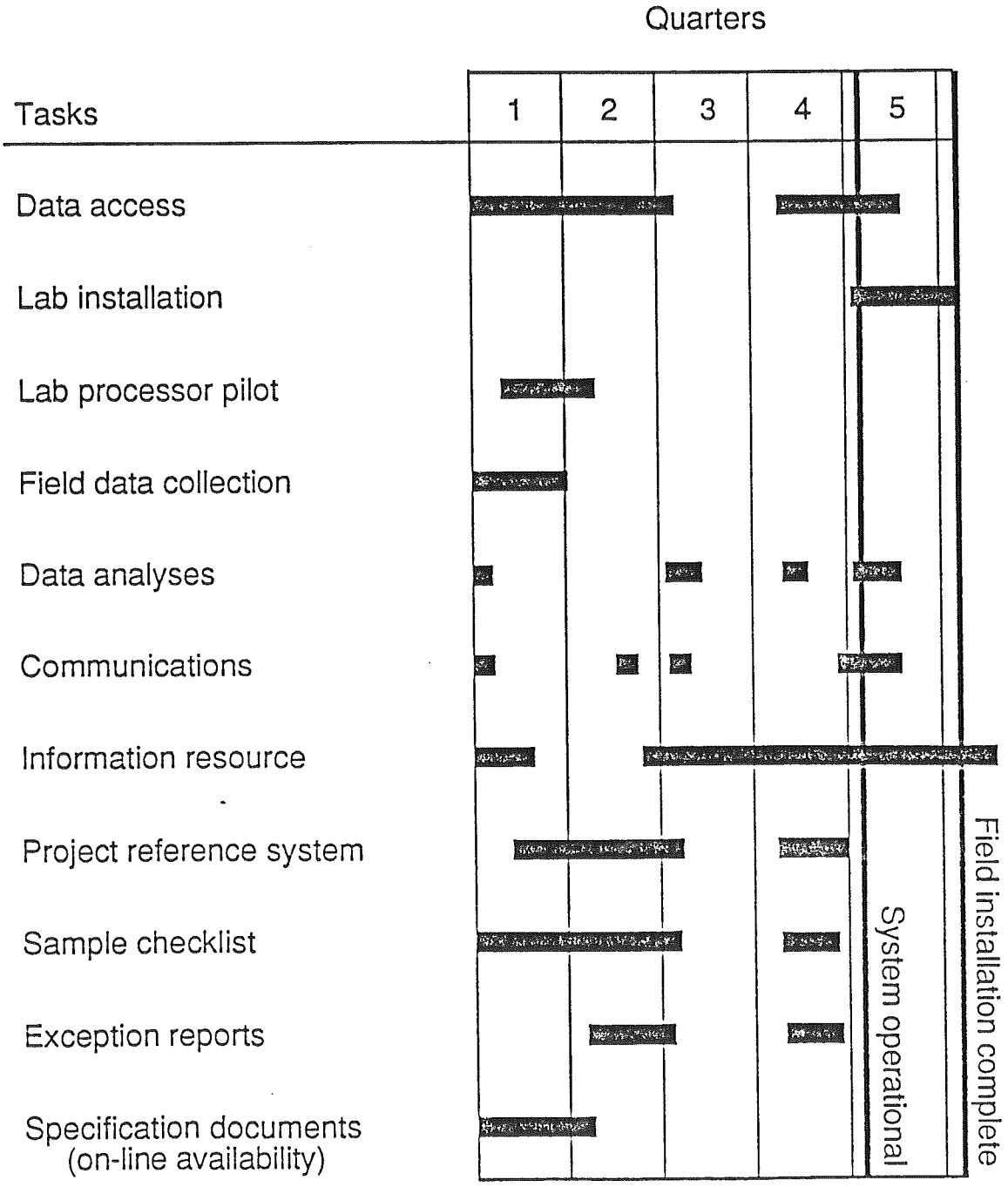
5. Establish a team to investigate the requirements to :

   a. Automate ADOT specification development and revision process (beyond just document word-processing.)
   b. Provide automatic passing of ADOT materials test criteria to the Materials Test System.
   c. Provide on-line inquiry and revision for all project specification documents.
   d. Provide on-line historical tracking and archiving for all project specification documents

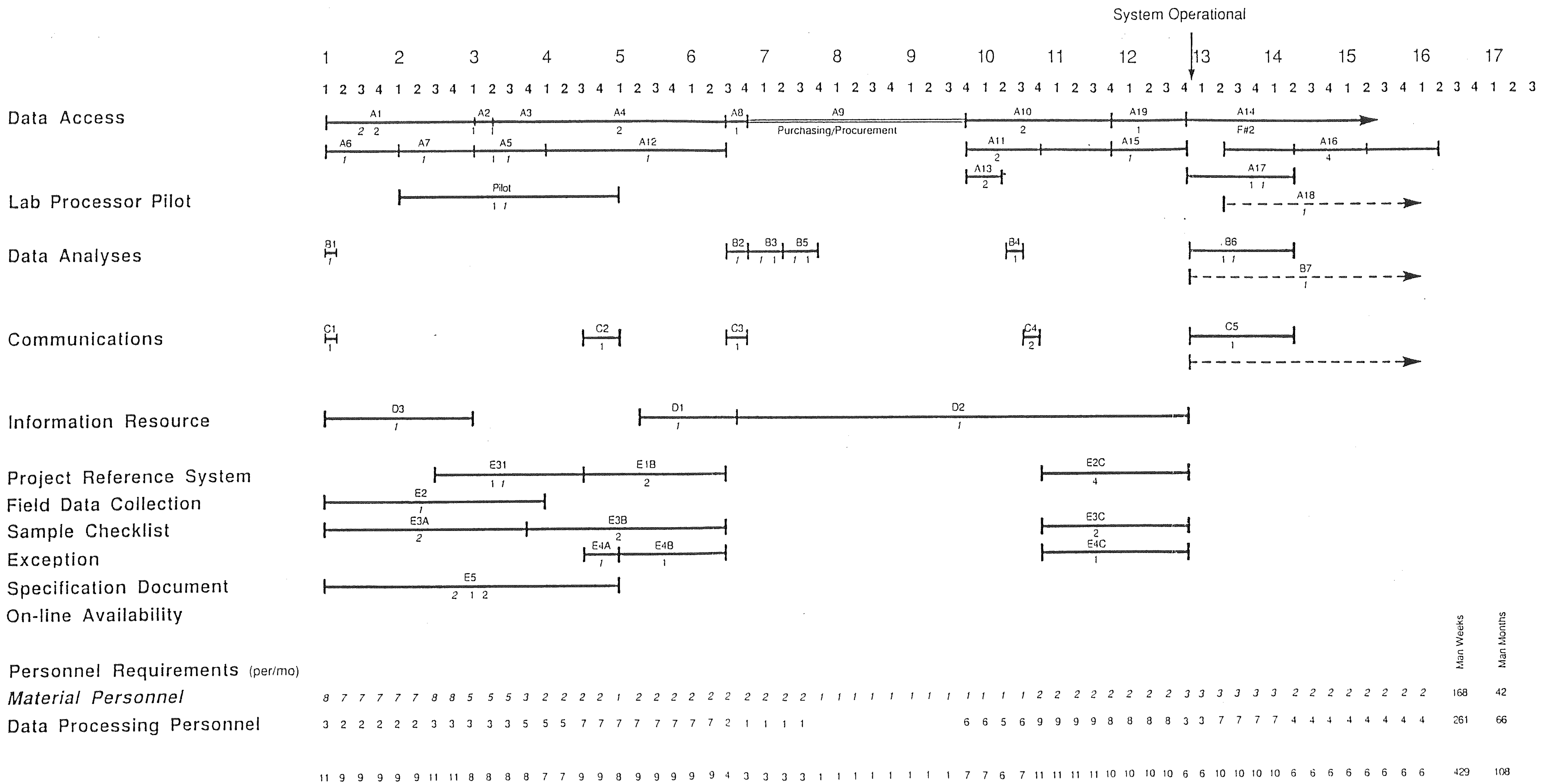
IMPLEMENTATION

The following pages define the estimated personnel requirements, the relative timing and the estimated duration of the tasks necessary to implement the proposed solution.

IMPLEMENTATION SCHEDULE



IMPLEMENTATION PLAN



JUSTIFICATION

CONSTRUCTION MATERIALS TESTING

AND

QUALITY ASSURANCE

STUDY

JUSTIFICATION

The justification is separated into two categories, tangible and intangible. The items identified by the tangible justification are some of the more obvious areas of impact. This area may be expanded upon if additional time is available for study. The intangible items such as increases in credibility are not expressed in time or dollars.

The tangible justification is based upon estimates of the number of samples tested on an annual basis. In addition, estimates have been made of the time required for specification research by laboratory and project personnel. These estimates along with some time studies have been translated into man hours and dollars with a Department defined rate.

TANGIBLE JUSTIFICATION

I. - COMPUTATION OF ANTICIPATED SAMPLES

The number of anticipated samples is derived from the Correlation Samples that are run in each of the District Laboratories. There is one sample sent to the District Laboratory for each five acceptance samples taken in the Field for Soil, Soils and Aggregate and Asphaltic Concrete. In addition, there are other acceptance tests performed by the District and Central Laboratories. The following is an estimate of the total number of samples that is expected to develop from the current five year construction program for each year.

A. Correlation Samples

District I	3,719
District II	1,034
District III	1,986
District IV	2,700
Total	9,439

B. Concrete Cylinders

Individual Tests	23,436

C. District Laboratory Miscellaneous Samples

Miscellaneous	2,360

D. Central Laboratory

Reinforcement Items	6,000
Bitumen	600
Chemistry (Specialty Items)	1,247

E. Total Tests

Acceptance Samples	47,195
Correlation Samples	9,439
Independent Assurance Samples	1,180
Reference Samples	370
Sub-Total (Except P.C. Conc, Bitumen & Specialty)	58,184
Concrete Cylinders(sets)	5,859
Reinforcement	6,000
Bitumen	600
Chemistry	1,247
District Lab. Specialty	2,360
TOTAL	74,250

F. Tests Distribution

Sieve Analysis	45,383
Bin Composites (4 Bin)	2,327
Moisture - Density Relations	1,745
Extraction - Gradation (with Voids Analysis)	8,729

II. - EXISTING SYSTEM IMPACT

The estimated impact to the existing system for the installation of an automated materials data management system is based upon the estimated number of samples in Item I. and a time study in an actual laboratory environment. Additional information was developed from interviews with project personnel that are responsible for preparing the necessary project test data logs, such as the weekly logs, running logs of portland cement concrete cylinder tests and running logs of asphaltic concrete acceptance tests.

A. Actual Calculation Times

	Calculation (Mins)	Checking (Mins)
Sieve Analysis	3.33	1.10
Bin Composite (4 Bins)	16.61	5.02
Extraction - Gradation (With Voids Analysis)	17.51	6.50
Moisture - Density Relations w/ Sieve	19.78	2.88

B. Estimated System Impact Due to Reduction in Calculations

Sieve Analysis $\frac{45{,}383 \times 4.43}{60} = 3{,}351$ man-hrs

Bin Composite $\frac{2{,}327 \times 21.63}{60} = 839$ man-hrs

Moisture - Density Relations $\frac{1{,}745 \times 22.66}{60} = 659$ man-hrs

Extraction - Grad. $\frac{8{,}729 \times 24.01}{60} = 3{,}493$ man-hrs

Concrete Cylinders	$\frac{5,859 \times 1.0}{60}$	=	98 man-hrs
Reinforcement	$\frac{6,000 \times 0.45}{60}$	=	45 man/hrs
TOTAL MAN HOURS			8,485 MAN - HRS

C. Estimated System Impact Due to Reduction in Logging Time

There are several transcriptions of test results from one document to another throughout the Department. An automated system that would generate the necessary reporting from the original data capture will have significant impact upon the system in terms of man hours. The estimate is based upon a reduction of 3.5 man hours per day for each of the 29 Construction ORGs in Highway Operations.

1. Field Office or Project Lab	
3.5 hrs x 29 Orgs x 260 days =	26,390 Man-hrs
2. Duplicate A. C. Logs	
10 Mins x 8729 Samples =	1,455 Man-hrs
3. Area Labs	
Three of the Area Labs Spend 2 Hours per Day Copying Test Reports for Transmittal	
2 hrs x 3 labs x 260 days	1,560 Man-hrs
TOTAL POTENTIAL IMPACT DUE TO LOGGING REDUCTION	29,405 Man-hrs

D. Estimated System Impact from Reduction in Specification Research

The Highway Operations Group has 530 personnel involved in Construction Administration. It is estimated that 375 people spend approximately 1/2 hour daily involved in specification research. The proposed ultimate automated system will provide a Specification Library that may be accessed from all locations thereby reducing this effort to only the time required to assimilate and interpret the specification.

The 530 total construction personnel have been reduced by an appropriate amount to 375 for those such as office men, surveyors and scale men that would not be involved in specification research.

In addition to the project efforts with respect to specification research, it is further estimated the laboratory personnel will spend an average of 5 minutes per sample to retrieve the applicable specifications for the required test characteristics.

The estimated impact is as follows:

375 Men x 0.5 Hrs =	187.5 Man-hrs Per Day
187.5 Man-Hrs x 260 =	48,750 Man-hrs Per Year
$\frac{58,184 \text{ Samples} \times 5 \text{ Mins.}}{60}$ =	4,849 Man-hrs Per Year
TOTAL SYSTEM IMPACT FROM REDUCTION IN SPECIFICATION RESEARCH	53,599 Man-hrs Per Year

E. Summary

Impact from Reduction of

Calculations	8,485 Man-hrs
Logging	29,405 Man-hrs
SUB-TOTAL	37,890 Man-hrs Per Year

These Man-hrs represent 21.3 Man - years per year based upon 1776 available man hours per year.

At an average employee cost of $26.00 per hour this has an estimated dollar value of

$983,550.00

Impact from Reduction of

Field Specification Research	48,750 Man-hrs
Lab Specification Research	4,849 Man-hrs
SUB-TOTAL	53,599 Man-hrs Per Year

These Man-hrs represent 30.2 Man - years per year based upon 1776 available man hours per year per employee

At an average employee cost of $26.00 per hour this has an estimated dollar value of

$1,394,515.00

TOTAL $2,378,065.00

INTANGIBLE JUSTIFICATION

This study has not been conducted in sufficient detail to identify all areas of "tangible" benefit from the automation of the materials data and information management. However, it does definitely indicate the potential economic impact to justify the apparent expenditure for the automation system. The foregoing discussion will attempt to identify other areas of justification, some definitely intangible, but others that may be associated with economic impact if additional study were conducted.

A. Claims

On an annual basis there are Contractor claims filed that amount to from 30 to 40 million dollars. It is estimated that approximately 40 percent are related to materials or materials testing difficulties. Of this 40 percent there is an estimated 10 percent settled by payment. This does not include change orders that may be negotiated due to some materials related problem. The substance of these claims may include some testing that may well be a result of poor communication between the laboratory support function and project administration. However, it is not justifiable to state an automated system would mitigate all of those claim settlement costs but it would certainly minimize those losses through the development of more precise and timely information.

An automation system will impact the record research that is associated with administering all claims that develop from materials related items. Currently, there is a duplication of record research throughout the Department at all levels of management to identify a resolution to a claim situation. The immediate access to all information would allow any manager to identify the information he needs to provide input into the administration of any claim. The same scenario would apply to management approval of change orders and force accounts. The quicker response time with more credible information and decisions could eventually influence the bidding process and result in additional savings.

B. Independent Assurance Program

The requirements for the Independent Assurance Program are established in the Federal Register, 23 CFR Part 637, entitled "Sampling and Testing of Materials and Construction". This requirement was adopted by final rule making on November 7, 1986. The Federal Highway Administration, based upon the Federal Register, developed the policies, procedures, and guidelines relating to sampling and testing of materials and construction in Federal-aid highway projects. This is identified in Volume 6, Chapter 4, Section 2, Subsection 7 of the Federal-Aid Highway Program Manual.

The Federal Register imposes the following regulation on each State Highway Agency.

> Independent assurance sampling and testing shall be performed by State personnel who have no direct responsibility for acceptance sampling and testing using test equipment other than that assigned to the project. The program may permit a reasonable portion of the independent samples and tests to be accomplished by independent observation of the acceptance sampling and testing.
>
> A prompt comparison of acceptance test results with independent assurance test results and documentation of that comparison

This program is currently being initiated in the Department. The requirement of independent sampling and prompt comparison with specific documentation exceeds the personnel resource that currently exists for that activity. The prompt comparison requires the District Materials Engineer to have access to all project acceptance test results. Additionally, the comparison must currently be accomplished by manual efforts. This generally requires considerable research and manual effort to develop a comparison based upon an opinion, rather than scientific fact through some statistical evaluation.

The total automation of the materials data and information management will allow the required comparisons and documentation to be performed electronically; otherwise, it appears beyond the current personnel resource plan to meet the requirements of F.H.P.M. 6-4-2-7.

C. Other Impacts

The automation of the materials data and information will create a historical database that can provide information for improved modeling of pavement performance as a function of the quality of materials incorporated into the construction. This may allow the Department to better predict the maintenance needs and consequently the service life of the highway system.

This database will provide a library of information that may be accessed for the purpose of specification development and revision. At best, the current procedures require manual research or rely upon an individual's recall.

There is a considerable amount of redundant copying and filing that is performed throughout the Department. The creation of the proposed database will tend to eliminate these efforts as all interested parties will have access to the materials test data and information.

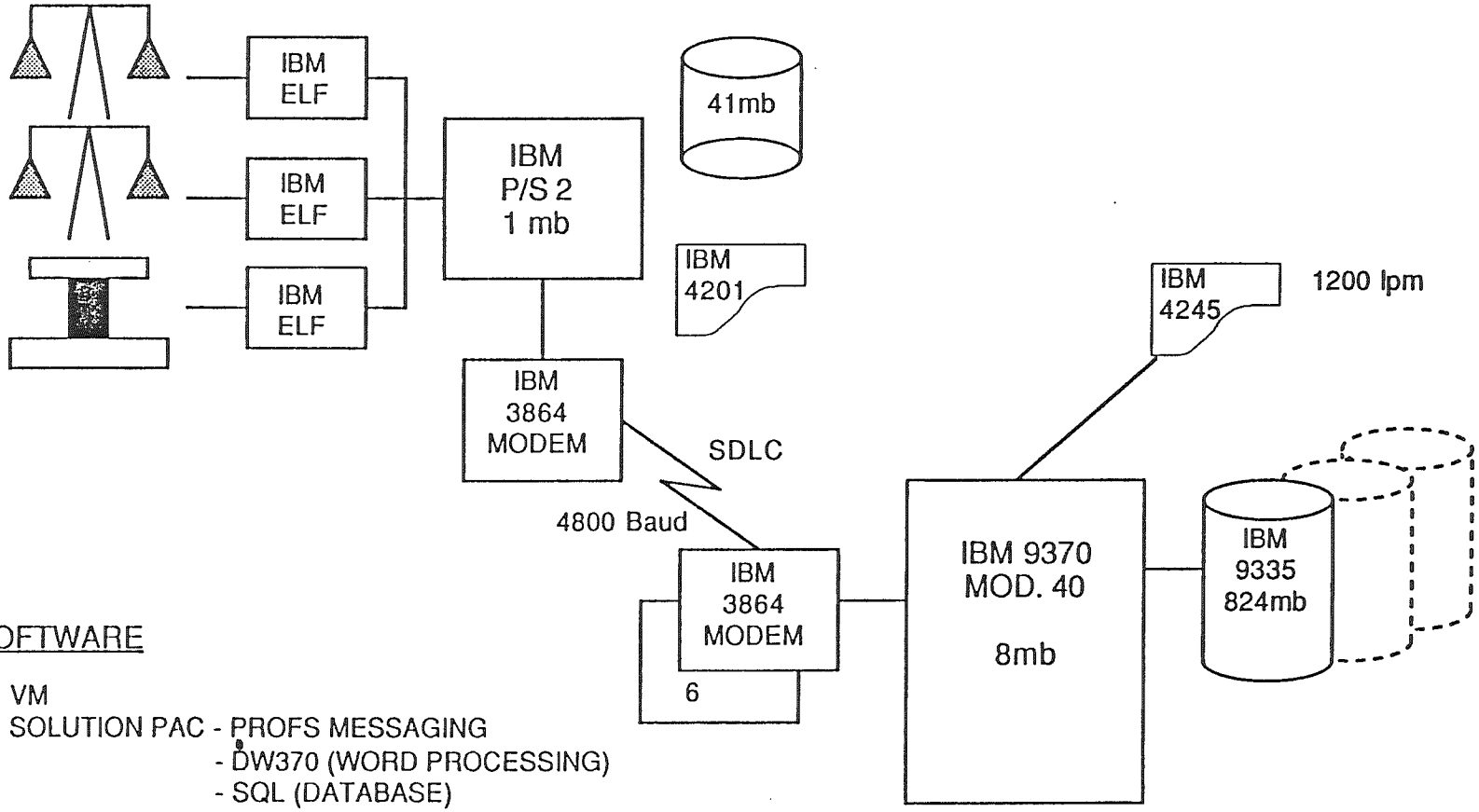
There are a number of audits performed at the project level for various investigations, including those for materials testing. The proposed system will allow the current audit procedures to be performed with a minimum of disruption and a minimum of the auditor's time. The efforts of quality assurance and quality control can be viewed as a form of audit.

General Laboratory Configuration

The proposed Laboratory Processor is an IBM PS/2 Model 60 with keyboard, color monitor, printer, hard disk and a modem for communicating with the Host Processor at ADOT Highway Division Headquarters. Each Laboratory Processor will control two or more Electronic scales through IBM 7494-ELF intelligent industrial terminals. Each terminal will interface with one scale. There will be one Laboratory Processor in each of the 23 existing Laboratories.

Test data will be read directly from the scales and stored on the hard disk of the Laboratory Processor. The Laboratory Processor will compare the test data with project specifications and store the test results with the test data. With the approval of the project engineer, the test data and test results will be transmitted to the IBM 9370 Host Processor at ADOT Highway Division Headquarters where it will be available for inquiry by all interested and authorized users.

SYSTEM REQUIREMENTS



SOFTWARE

VM
SOLUTION PAC - PROFS MESSAGING
- DW370 (WORD PROCESSING)
- SQL (DATABASE)
- QMF (INQUIRY)

COSTS

HARDWARE COSTS

		Quantity	State Purchase Price	Annual Maintenance
9375-040	Processor	1	$ 83,200	$ 280
9335-A01	DASD Controller	1	6,800	18
9335-B01	DASD	2	34,000	100
9309-002	Rack Enclosure	2	4,800	8
1589	Tape & Controller	1	44,000	395
4245-D12	Printer	1	26,660	250
3864-002	Modem, 2-Wire	92	220,486	15,670
3299-002	Terminal Multiplexer	2	954	NA
	PS/2 Model 50	63	215,336	180
	PS/2 Model 60	23	104,421	190
7494-012	Elf	46	69,368	
HARDWARE TOTAL:			$810,025	

SOFTWARE COSTS

	Quantity	State Purchase Price
9375-040 Software		
SolutionPac	1	$101,580
VM/IS PROFS AS DW/370 SQL QMF PC File Transfer VM/RSP Support		
PS/2 Software (Model 60)	23	14,812
3270 Emulation Program (Model 50)	63	40,572
IBM DOS 3.3 OS/2 V1.1		
PC Software*	1	417
PC 3270 Emulation Program IBM DOS 3.3		
SOFTWARE TOTAL:		$156,964

*Excluded from Software Total.

INVESTMENT

Hardware	$ 810,000
Software	157,000
Personnel	
Highway Operations	161,000
Data Processing (ISG)	360,000
	or
(contract)	780,000
	$1,488,000
	or
	$1,908,000